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Discards of Atlantic Cod, Haddock, and Yellowtail Flounder from the 2005 and 2006 Canadian Scallop Fishery on Georges Bank

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ABSTRACT

Discards of Atlantic cod, haddock and yellowtail flounder from the 2006 Canadian scallop fishery on Georges Bank were estimated from 11 observed trips. Data were insufficient to determine spatial differences in discard rates per hour but temporal trends were accounted using a 3-month moving window calculation. Discards were estimated by applying the monthly discard rate per hour obtained by the 3-month moving window calculation to the total monthly effort in hours of the scallop fleet. Total annual estimated discards in 2005 and 2006 were highest for yellowtail flounder, at 255 mt and 565 mt respectively, and intermediate for Atlantic cod, at 87 mt and 117 mt respectively, while those for haddock were lowest, at 50 mt and 67 mt.

RÉSUMÉ

On a estimé les rejets de morue, d'aiglefin et de limande à queue jaune dans la pêche canadienne du pétoncle de 2006 pratiquée sur le banc Georges d'après les données recueillies par des observateurs lors de 11 sorties de pêche. Ces données se sont avérées insuffisantes pour déceler des différences spatiales dans les taux de rejet par heure, mais on a pu, cependant, établir des tendances temporelles (trimestrielles). Pour estimer les rejets, on a appliqué le taux de rejet mensuel par heure observé par l'effort trimestriel total à l'effort mensuel total de la flottille de pétoncliers. Les totaux annuels de rejets estimatifs les plus élevés en 2005 et en 2006 ont été ceux de la limande à queue jaune, 255 tm et 565 tm respectivement; la morue se classe au milieu, avec 87 tm et 117 tm respectivement, tandis que les rejets d'aiglefin ont été plus bas, à 50 tm et 67 tm.

Introduction

Management measures established in 1996 prohibit the landing of groundfish (except monkfish) by the Canadian scallop fishery on Georges Bank. All incidental catch of Atlantic cod, haddock and yellowtail flounder in 2006 was therefore discarded. Discards, pre or post 1996, were not recorded in the scallop fishery statistics. Discards of Atlantic cod, haddock and yellowtail flounder from the Canadian scallop fishery for 1960-2004 were estimated by Van Eeckhaute et al (2005) and updated for 2005 (Van Eeckhaute and Gavaris, 2006). This analysis updates the Canadian scallop fishery discard estimate series for 2006 and revises 2005 results. Previous analyses have simply summed effort for scallop draggers that land frozen product (freezer trawlers) and those that land fresh product (wet fish). There is evidence that the fishing efficiency of these two fleets differs and a conversion factor was derived using available data from 2004-2006. In summary, the analyses conducted employed data from the following periods:

Result	Period
2006 discards	January – December 2006
2005 discards	January – December 2005
freezer trawler : wet fish conversion	January 2004 –September 2006

Data and Methods

Prorating

Any incidental catch that is not landed, i.e., is not recorded in the fishery statistics records, is designated as "discards". Discards of Atlantic cod, haddock and yellowtail flounder in the scallop fishery on Georges Bank were estimated by applying the discard rate in kg/hour obtained from observed trips to the total scallop effort hours.

discards = total scallop effort x *(observed discards / observed scallop effort)*

This approach is dependent on the assumption that the population density of the incidentally caught species experienced by observed trips, i.e. the (*observed discards / observed scallop effort*) ratio, is representative for the whole scallop fishery. Therefore, results can be sensitive to inadequate sampling of the spatial/temporal variation in the population density of the incidentally caught species.

For earlier years where extensive interpolation was required to compensate for missing observations, prorating on the basis of *observed discards / observed scallop effort* was considered to invoke fewer unverifiable assumptions than other options (Van Eeckhaute et al 2005). With more regular observer sampling since 2004, prorating on the basis of *observed discards / observed scallop landings* may also be considered. In principle, the ratio with the smaller variance would be preferable, assuming biases are negligible. The variance was calculated as

$$\hat{\sigma}_r = \sqrt{\frac{\sum_i (D - rX)^2}{n-1}} \Big/ \overline{X}\sqrt{n} \quad \text{(Cochran 1977)}$$

where D represents observed discards, X represents either observed scallop effort or observed scallop landings, r is the respective ratio for each of these and n is sample size (number of observed trips used in calculating the ratio).

Effort Standardization

Prior to 2004, virtually none of the scallop landed was caught by freezer trawlers. The prevalence of freezer trawlers has increased rapidly in recent years with freezer trawler landings accounting for 34%, 57% and 63% in 2004 to 2006 respectively. Freezer trawlers operate differently and use somewhat larger dredges. The effective fishing intensity exerted by an hour of fishing by a freezer trawler may therefore not be equivalent to that of a wet fish trawler. To derive a conversion factor for standardizing effort, a multiplicative model (Gavaris 1980) with factors for fleet, area, month and year was considered using data from January 2004 to September 2006

$$U_{ijkl} = \mu\left(fleet_i^{X_i}\right)\left(area_j^{X_j}\right)\left(month_k^{X_k}\right)\left(year_l^{X_l}\right)\varepsilon_{ijkl}$$

where U_{ijkl} is the catch rate. The subscripts i, j, k and l index fleet (freezer trawler or wet fish), area (unit areas 5Zej or 5Zem), month (January – December) and year (2004-2006) respectively. The variables X are simply dummy variables indicating if the catch rate corresponds to a particular fleet, area, month and year when the value is 1 and have a value of 0 otherwise. Preliminary analyses and exploratory investigation of the data (Figure 1) indicated insufficient and highly variable catch rates for unit area 5Zem. Accordingly, data from unit area 5Zem were excluded and the area factor was dropped leaving

$$U_{ikl} = \mu\left(fleet_i^{X_i}\right)\left(month_k^{X_k}\right)\left(year_l^{X_l}\right)\varepsilon_{ikl}.$$

Taking logarithms, this was solved using ordinary least squares. Factor effects for any fleet, month or year, are simply the regression coefficients (θ) retransformed back to the linear scale (ϕ), i.e. $\phi = e^{\theta}$. Assuming that ε are distributed according to a Gaussian distribution, an unbiased estimator of the factor effects is given by

$$\hat{\phi} = e^{\hat{\theta}} g_{\nu}\left[-\frac{\nu+1}{\nu}\frac{\hat{\sigma}_{\theta}^2}{2}\right] \text{ (Bradu and Mundlak 1970)}$$

where ν are the degrees of freedom and $g_{\nu}(arg)$ can be approximated by e^{arg} for sufficiently large degrees of freedom (Ebbeler 1973).

An estimate of the variance of the factor effects is given by

$$e^{2\hat{\theta}}\left\{g_{\nu}^2\left[-\frac{\nu+1}{\nu}\frac{\hat{\sigma}_{\theta}^2}{2}\right] - g_{\nu}\left[-\frac{\nu+1}{\nu}2\hat{\sigma}_{\theta}^2\right]\right\} \text{ (Bradu and Mundlak 1970).}$$

Results and Discussion

The catch rate standardization regression of wet fish and freezer trawlers accounted for 65% of the total variation and the fit was reasonable, although some patterns in residuals were evident (Figure 2). The analysis of variance results indicated that the fleet factor was the dominant effect (Table 1). The seasonal pattern shows catch rates for scallops are highest during April to August (Figure 3). The conversion factor from wet fish hours to freezer trawler hours was estimated as 1.2 with a standard error of 0.05. This conversion

factor was applied to all the wet fish effort (both observed trips and fleet effort) to obtain standardized freezer trawler hours. All subsequent analyses were based on standardized freezer trawler hours.

Estimates of Atlantic cod, haddock and yellowtail flounder discards from the 2006 Canadian scallop fishery on Georges Bank were based on observed discards from 11 observed trips (Table 2). The spatial coverage of observed trips in relation to the fishery is illustrated by quarter in Figure 4. Fishing locations for observed trips in the second and fourth quarters do not appear to cover the full range of grounds fished by the fleet. In the second quarter, fishing activity on an eastern patch was missed. In the fourth quarter, fishing activity on a southwestern patch, close to an area referred to as the 'Yellowtail Hole', was missed. The yellowtail flounder discards on trip T2006-05 were particularly high and influential. This trip may be an outlier (Figure 5), but examination of trip details did not support its exclusion.

Effort refers to hours towed, with usually 2 dredges being towed at the same time. As there is no adjustment for the number of dredges or size of dredges, it is assumed that the amount of gear used on observed trips is representative of the amount of gear used in typical operations. Effort information for observed trips may be obtained from observer records or from fishery statistics. Since the fleet effort must be obtained from fishery statistics, effort from fishery statistics was also used for the observed trips to ensure consistency. Trip effort for the 2006 observed trips was obtained from fishery statistics, except one case where the observed number of dredges fished was pro-rated to effort using a proportional relationship because effort was not recorded in the fishery statistics. The effort for observed trips in 2006 comprised about 6% of total effort.

The fishery statistics effort represents the hours fished for an entire observed trip. The observed discards are only for the portion of the fishing activity that was observed. It is necessary therefore to prorate the observed discards to the discards for the entire observed trip. The number of dredge hauls that were observed and the total number of dredge hauls that were made on the trip were recorded. The total discards for a trip was obtained by prorating the observed discards by the ratio of total number of dredges to observed number of dredges recorded for the trip.

Both temporal and spatial patterns in discard rates might be expected, but there were not enough observed trips in 2006 to calculate discard rates by area, as unit area 5Zem had limited observer coverage. Seasonal patterns in discard rates were taken into account by applying calculations using a 3-month moving window. The seasonal pattern in discard rates tended to be more pronounced and consistent for yellowtail flounder with higher rates (kg/hr) during the spring and early summer (Figure 6). To estimate discards, the monthly discard rates were applied to the total monthly effort of the scallop fleet. Monthly and annual cumulative estimated discards for 2005 and 2006 are given in Table 3. Both the effort standardization and application of a 3-month moving window contributed to the revision of the 2005 discards (Table 4). Total annual estimated discards in 2005 and 2006 were highest for yellowtail flounder, at 255 mt and 565 mt respectively, and intermediate for Atlantic cod, at 87 mt and 117 mt respectively, while those for haddock were lowest, at 50 mt and 67 mt. As noted above, 2006 results, particularly for yellowtail flounder, were influenced by one trip. An illustrative sensitivity analysis excluding that trip reduced discards to 210 mt for yellowtail flounder, 105 mt for cod and 55 mt for haddock.

Observed scallop landings are more readily available and prorating on the basis of scallop landings circumvents effort standardization. With less than three years of regular observer sampling for comparison, it was considered premature to change the prorating basis at this time. However, this preliminary comparison indicates that both ratios display similar variance (Figure 7), suggesting that prorating on the basis of observed discards / observed scallop landings may be a practical option worthy of further investigation.

In the absence of reliable survival estimates, all discarded Atlantic cod, haddock and yellowtail flounder are assumed dead for the purpose of stock assessment computations. Scallop fishing practice may result in intensive localized fishing activity. Observers on scallop trips have noted on occasion, that what appears to be the same fish may be caught more than once. Counting a fish more than once if it is captured multiple times may result in over-estimation of discards. The prevalence of multiple captures is thought to be low. Nevertheless, a new practice was introduced for observed trips in 2007 to fin clip yellowtail flounder, and possibly cod and haddock, that are returned to the water. Fin clipped fish that may be subsequently recaptured are distinguished in the records. It is intended that these fin clipped fish be excluded from discard calculations to counter the potential for over-estimation.

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Table 1. Analysis of variance from the multiplicative analysis of wet fish and freezer trawler catch rate from the Canadian scallop fishery in unit area 5Zej.

Source	Degrees of Freedom	Sums Of Squares	Mean Squares	F-Value
Intercept	1	1344.000		
Regression	14	2.355	0.168	6.114
Fleet	1	0.508	0.508	18.477
Month	11	0.812	0.074	2.682
Year	2	0.694	0.347	12.622
Residuals	47	1.293	0.028	
Total	62	1348.000		

Table 2. Observed trips for the Canadian Georges Bank scallop fishery in 2006.

			Proration			Discards (kg)						Effort (hrs)
			Dredges			Yellowtail Flounder		Cod		Haddock		
Trip ID	Board Date	Land Date	Obs.	Total	Prop.	Observed	Prorated	Observed	Prorated	Observed	Prorated	
T2006-1	2/7/2006	2/10/2006	57	81	0.70	50	71	167	237	80	114	32.4
T2006-2	3/6/2006	3/15/2006	394	584	0.67	653	968	210	311	137	203	144
T2006-3	4/4/2006	4/20/2006	308	586	0.53	1233	2346	1751	3331	218	415	147
T2006-4	5/16/2006	5/24/2006	202	305	0.66	1762	2660	117	177	26	39	96[1]
T2006-5	6/9/2006	6/27/2006	655	1258	0.52	12215	23460	399	766	404	776	287
T2006-6	7/13/2006	8/8/2006	1011	1353	0.75	2968	3972	326	436	468	626	331
T2006-7	8/11/2006	8/25/2006	384	774	0.50	311	627	248	500	236	476	194
T2006-8	10/3/2006	10/13/2006	280	574	0.49	269	551	187	383	90	185	222
T2006-9	10/23/2006	11/7/2006	434	788	0.55	657	1193	36	65	16	29	230
T2006-10	11/20/2006	12/1/2006	280	451	0.62	130	209	170	274	172	277	195.6
T2006-11	12/1/2006	12/23/2006	684	1365	0.50	313	625	936	1868	581	1159	359

[1] effort derived from average hours per dredge

Table 3. Discards from the Canadian scallop fishery on Georges Bank for 2005 and 2006 calculated using a 3 month moving window discard rate.

	Discard Rate (kg/hour)			Effort	Discard (mt)			Cum Annual Discard (mt)		
2005	Yellowtail	Cod	Haddock		Yellowtail	Cod	Haddock	Yellowtail	Cod	Haddock
Jan	4.826	4.734	2.206	156	1	1	0	1	1	0
Feb	4.506	2.900	2.017	589	3	2	1	3	2	2
Mar	4.112	2.231	1.499	3779	16	8	6	19	11	7
Apr	7.455	2.330	1.301	3669	27	9	5	46	19	12
May	11.692	4.022	0.624	2334	27	9	1	74	29	13
Jun	24.093	3.156	2.341	1800	43	6	4	117	34	18
Jul	20.072	2.739	2.335	2123	43	6	5	160	40	23
Aug	16.372	2.196	1.970	4184	69	9	8	228	49	31
Sep	2.539	2.290	1.361	3329	8	8	5	237	57	35
Oct	2.014	2.122	1.432	3589	7	8	5	244	65	41
Nov	1.833	3.878	1.754	4003	7	16	7	251	80	48
Dec	1.747	3.295	1.190	2126	4	7	3	**255**	**87**	**50**

	Discard Rate (kg/hour)			Effort	Discard (mt)			Cum Annual Discard (mt)		
2006	Yellowtail	Cod	Haddock		Yellowtail	Cod	Haddock	Yellowtail	Cod	Haddock
Jan	2.193	7.325	3.509	507	1	4	2	1	4	2
Feb	5.890	3.110	1.796	557	3	2	1	4	5	3
Mar	10.466	11.998	2.262	343	4	4	1	8	10	4
Apr	15.437	9.869	1.698	1931	30	19	3	38	29	7
May	53.711	8.065	2.321	3033	163	24	7	201	53	14
Jun	42.147	1.932	2.019	3383	143	7	7	343	60	21
Jul	34.556	2.097	2.313	3788	131	8	9	474	68	29
Aug	8.760	1.783	2.099	4350	38	8	9	512	75	39
Sep	2.832	2.123	1.587	4540	13	10	7	525	85	46
Oct	3.017	1.116	0.758	4670	14	5	4	539	90	49
Nov	2.561	2.573	1.639	5073	13	13	8	552	103	58
Dec	2.583	2.813	1.868	4817	12	14	9	**565**	**117**	**67**

Table 4. Decomposition of the effect due to effort standardization and the 3-month moving window approach on the revisions to total annual discards from the Canadian scallop fishery on Georges Bank for 2005.

2005 Discards (mt)	*Effort Not Standardized*		*Effort Standardized*	
By quarter	Yellowtail:	317	Yellowtail	286
	Cod:	110	Cod:	103
	Haddock:	52	Haddock:	50
By 3 month moving window	Yellowtail:	275	Yellowtail:	255
	Cod:	92	Cod:	87
	Haddock:	53	Haddock:	50

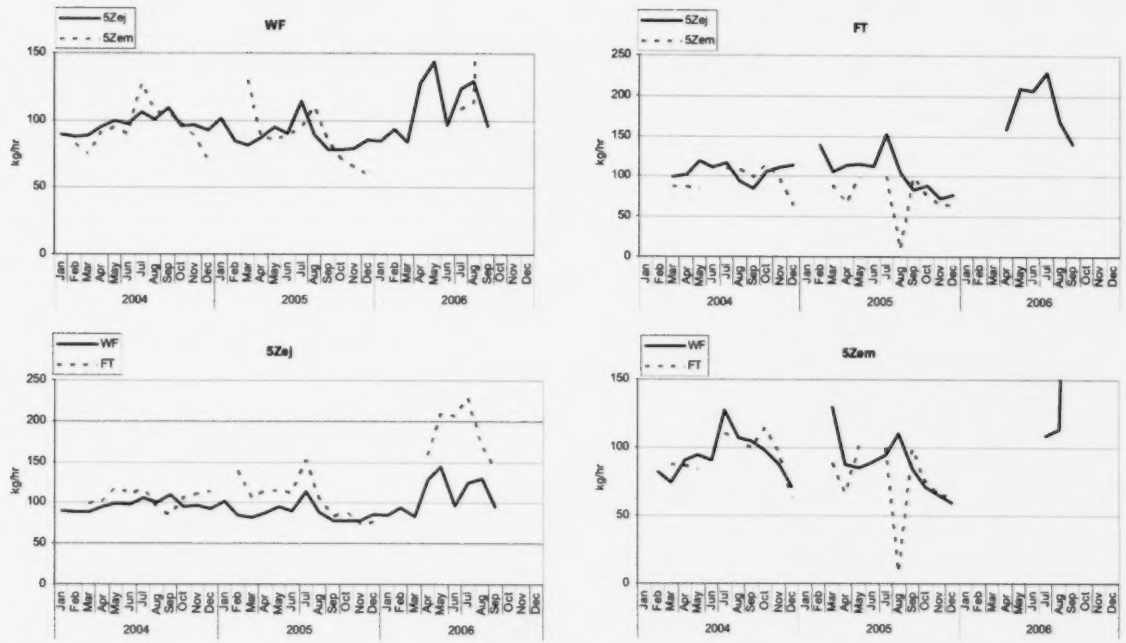

Figure 1. Catch rates for wet fish (WF) and freezer trawlers (FT) from the Canadian scallop fishery in unit areas 5Zej and 5Zem from January 2004 to September 2006.

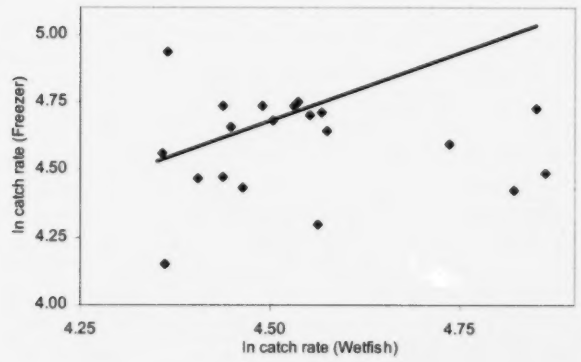

Figure 2. Scatterplot of ln catch rate for freezer trawler and wet fish boats from the Canadian scallop fishery in unit area 5Zej. The line represents the conversion factor.

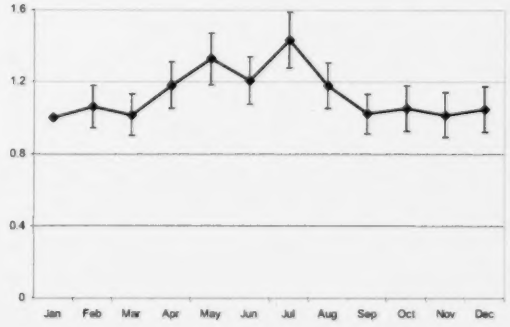

Figure 3. Seasonal pattern in scallop catch rate from multiplicative model for the Canadian scallop fishery in unit area 5Zej.

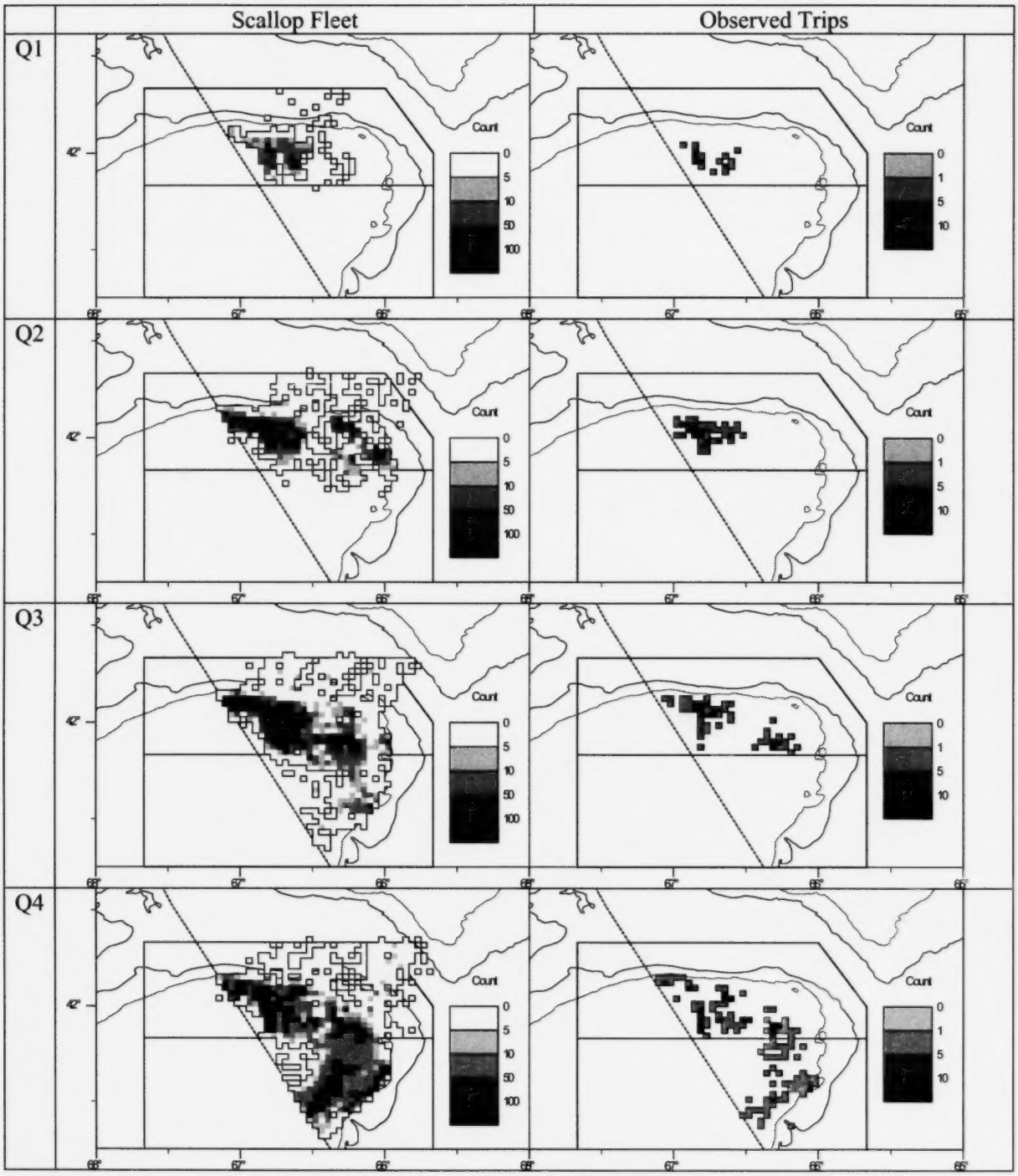

Figure 4. Fleet fishing locations based on count of VMS polls (left panels) compared to locations of observed fishing based on count of dredges (right panels) for the 2006 Canadian scallop fishery on Georges Bank.

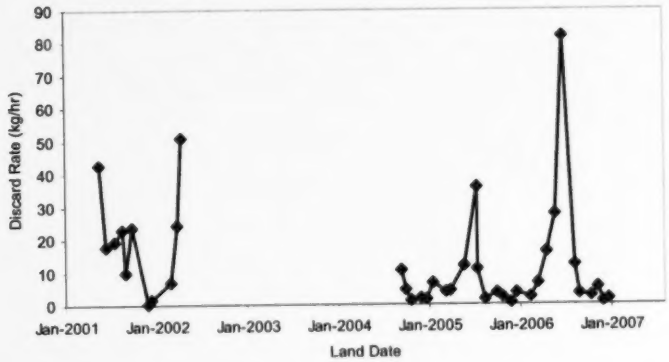

Figure 5. Discard rates (kg/hr) of yellowtail flounder for observed trips representative of commercial fishing.

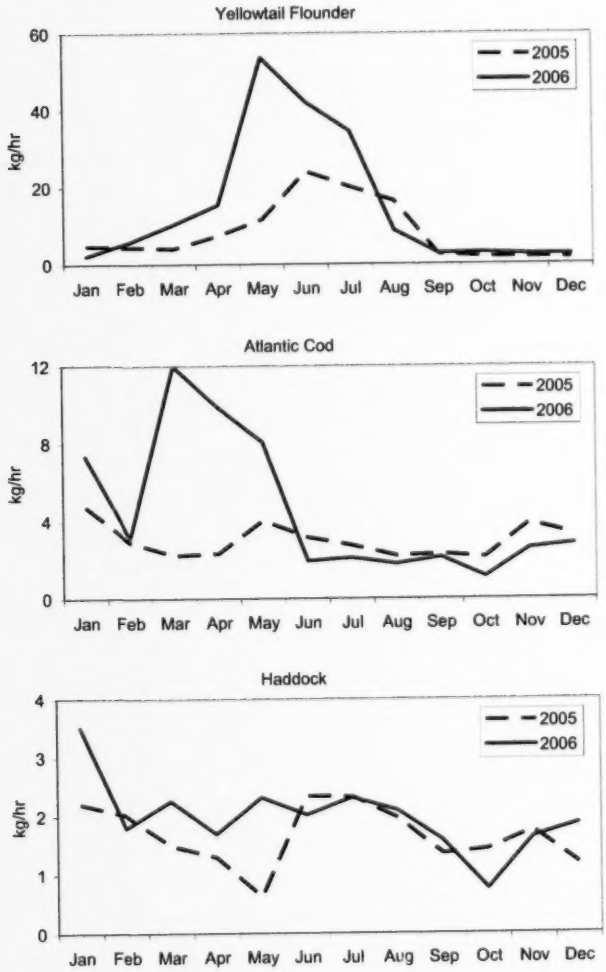

Figure 6. Seasonal patterns in discard rates of yellowtail flounder, Atlantic cod and haddock from the Canadian scallop fishery on Georges Bank in 2005 and 2006 calculated using a 3-month moving window.

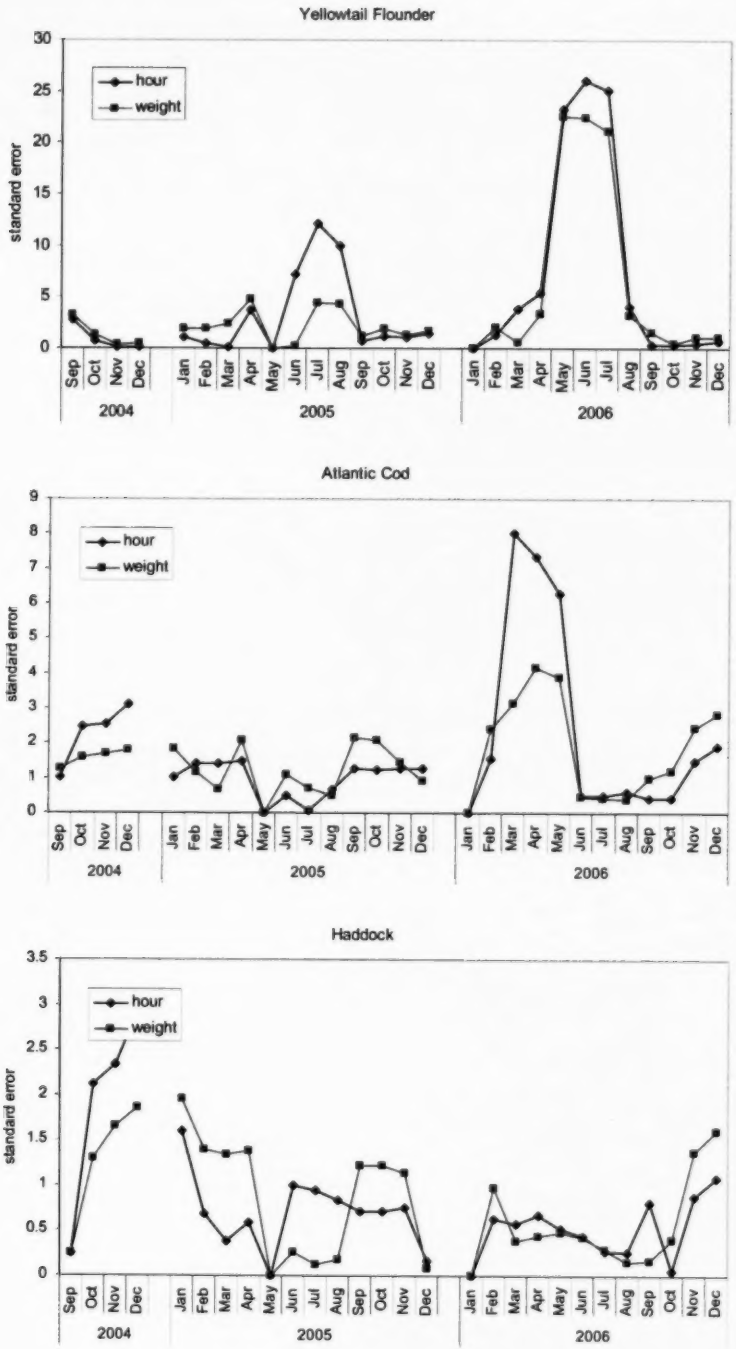
Yellowtail Flounder
standard error
hour
weight
Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
2004
2005
2006
Atlantic Cod
standard error
hour
weight
Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
2004
2005
2006
Haddock
standard error
hour
weight
Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
2004
2005
2006

Figure 7. Comparison of standard error for prorating by observed discards / observed hours versus observed discards / observed scallop landings from the Canadian scallop fishery on Georges Bank.